

CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
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Lecture 40 Lithography: Imaging Tools

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Reading:
Chapter 7, *Fabrication Engineering at the Micro- and Nanoscale*, 4th edition, Campbell

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Lithography Sequence

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History of Optical Lithography Imaging Tools

- Contact and Proximity Printing
 - From the beginning
- Perkin-Elmer Scanner (1973)
 - 1973, about 2 μm resolution, full wafer 1X scanner
- Step-and-Repeat Printers (1978)
 - Developed from photorepeaters for mask making
 - G-line, NA = 0.28; progressed to i-line, NA = 0.65
- Deep UV Steppers and Scanners (1988)
 - KrF Excimer Laser, 248 nm wavelength
- ArF 193 nm Scanners (1998)
 - Immersion enables NA up to 1.35

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Evolution of Lithographic Printing

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Contact Printing

- Contact printing
 - Soft: push up on wafer to make contact with mask
 - Hard: pull a vacuum between mask and wafer
 - Resolution limit: near light wavelength
- Problem: Defects
 - Every contact damages the mask
 - Masks can only be used for a certain number of prints before they become too defective
 - Defectivity is the true resolution limiter for contact printing!

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Proximity Printing

- Keep mask and wafer separated
 - About 20 μm gap is typical, due to wafer and mask non-flatness and tilt
- The gap limits resolution
 - Resolution $\propto \sqrt{\lambda g}$
- Used in manufacturing down to about 4 μm features

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Early Projection Tools

Exposure Field: the portion of the wafer that can be exposed at once

Mask

Wafer

1X Scanner Reduction Stepper

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Step-and-Scan

Slit width = 8 mm

Field size = 26 mm X 33 mm

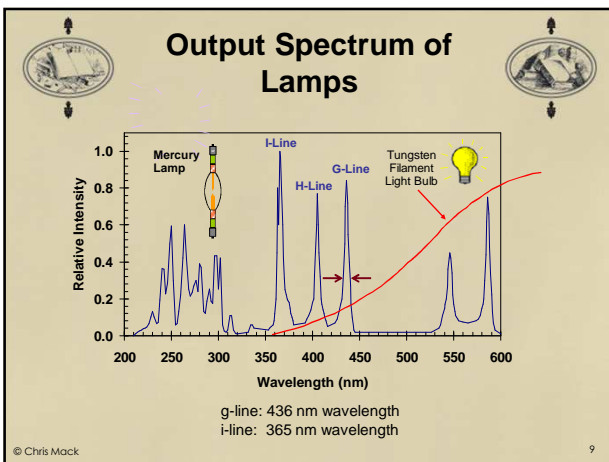
Scan Direction

Single Exposure Field

Wafer Pattern of Exposure Fields

All state-of-the-art tools use this approach today

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Excimer Laser

- Excimer: excited dimer
 - KrF: 248 nm wavelength
 - ArF: 193 nm wavelength
- Pulsed Operation
 - 4 – 6 kHz repetition rate
 - Bandwidth ~ 0.35 pm

(from cymer.com)

Future technology Current technology Ultra-Hi Voltage Mercury vapor lamp

SOR Excimer Laser i-line 365nm h-line 405nm

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Example Lithography Tools

From Nikon Corp.

From ASML

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Lecture 40: What have we Learned?

- What are the advantages and disadvantages of contact printing?
- What are the advantages and disadvantages of proximity printing?
- What are three ways of filling a wafer with exposed chip patterns during projection printing?
- What are the two most common mercury arc lamp wavelengths?
- What are the two common excimer laser types and wavelengths?

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